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(54) **SYSTEM AND METHODS TO CONFIGURE A QUERY LANGUAGE USING AN OPERATOR DICTIONARY**

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G06F 17/30 (2006.01)
G06F 21/62 (2013.01)

(52) **U.S. Cl.**
CPC ... ***G06F 17/30448*** (2013.01); ***G06F 17/30011*** (2013.01); ***G06F 17/30035*** (2013.01); ***G06F 17/30404*** (2013.01); ***G06F 17/30477*** (2013.01); ***G06F 17/30554*** (2013.01); ***G06F 21/6227*** (2013.01)

(58) **Field of Classification Search**
CPC G06F 7/30404
See application file for complete search history.

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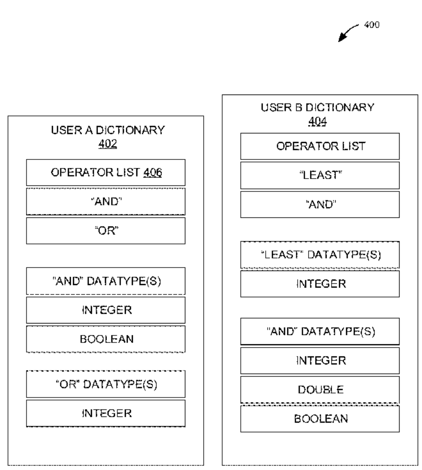
(57) **ABSTRACT**

Systems and methods to configure a query language using an operator dictionary are described. The system receives, from a first user, a search query to search for document information in a database. The system determines that terms of the search query from the first user are in accordance with dictionary information that corresponds to the first user. The dictionary information includes a first list of compatible query operators. The system applies the search query to the index data structure in the database to identify the document information. The system sends an electronic interface to the first user that includes the document information.

20 Claims, 8 Drawing Sheets



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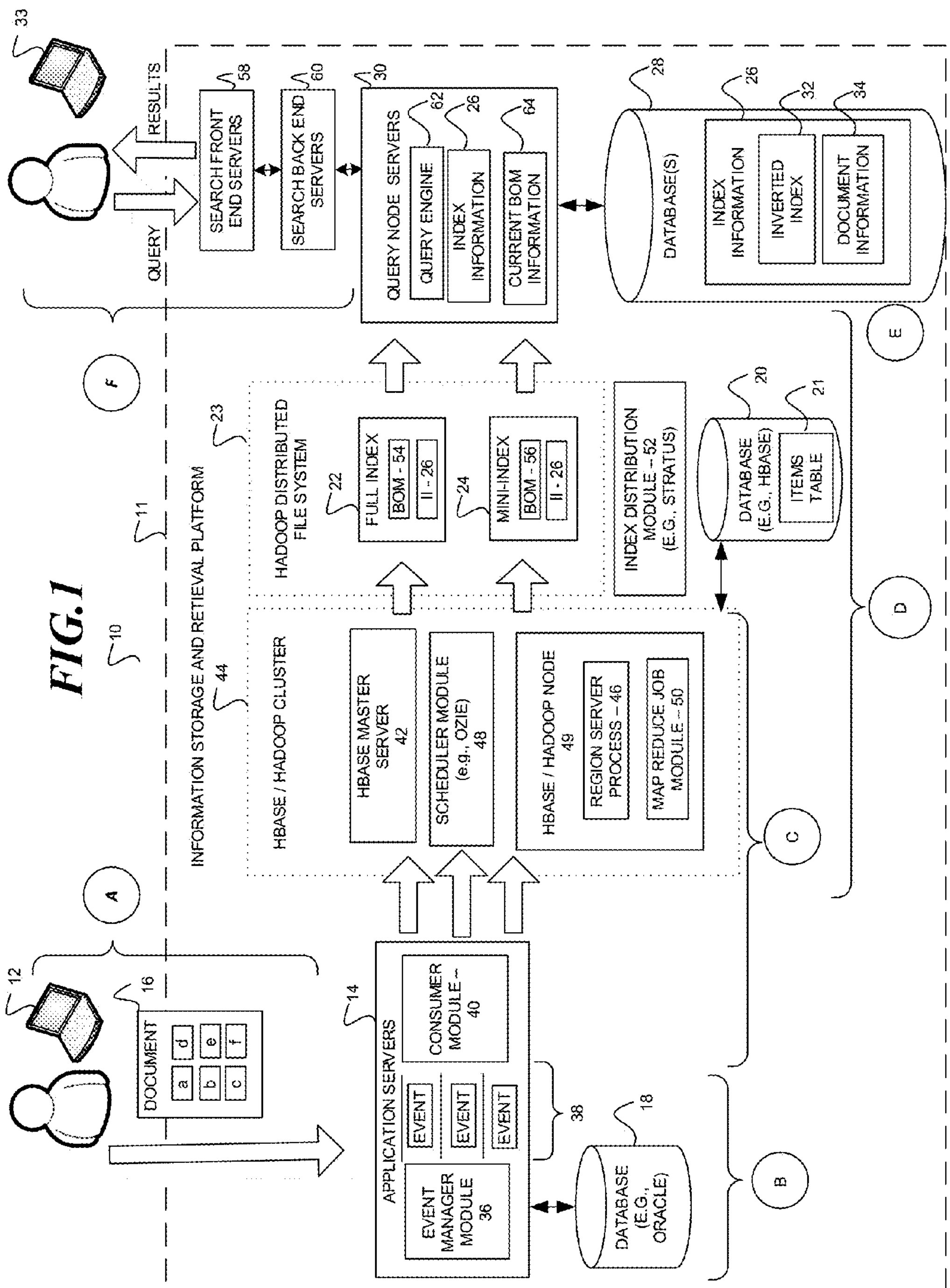

10
11
INFORMATION STORAGE AND RETIEVAL PLATFORM
12
16
DOCUMENT
a
b
c
d
e
f
A
14
APPLICATION SERVERS
EVENT MANAGER MODULE 36
EVENT
EVENT
EVENT
38
CONSUMER MODULE – 40
18
DATABASE (E.G., ORACLE)
B
44
HBASE / HADOOP CLUSTER
HBASE MASTER SERVER 42
SCHEDULER MODULE (e.g., OZIE) 48
HBASE / HADOOP NODE 49
REGION SERVER PROCESS – 46
MAP REDUCE JOB MODULE – 50
C
23
HADOOP DISTRIBUTED FILE SYSTEM
22
FULL INDEX
BOM - 54
II - 26
24
MINI-INDEX
BOM - 56
II - 26
INDEX DISTRIBUTION MODULE – 52 (E.G., STRATUS)
20
21
DATABASE (E.G., HBASE)
ITEMS TABLE
D
33
QUERY
RESULTS
F
58
SEARCH FRONT END SERVERS
60
SEARCH BACK END SERVERS
30
QUERY NODE SERVERS
62
QUERY ENGINE
26
INDEX INFORMATION
64
CURRENT BOM INFORMATION
28
DATABASE(S)
26
INDEX INFORMATION
32
INVERTED INDEX
34
DOCUMENT INFORMATION
E

FIG.1

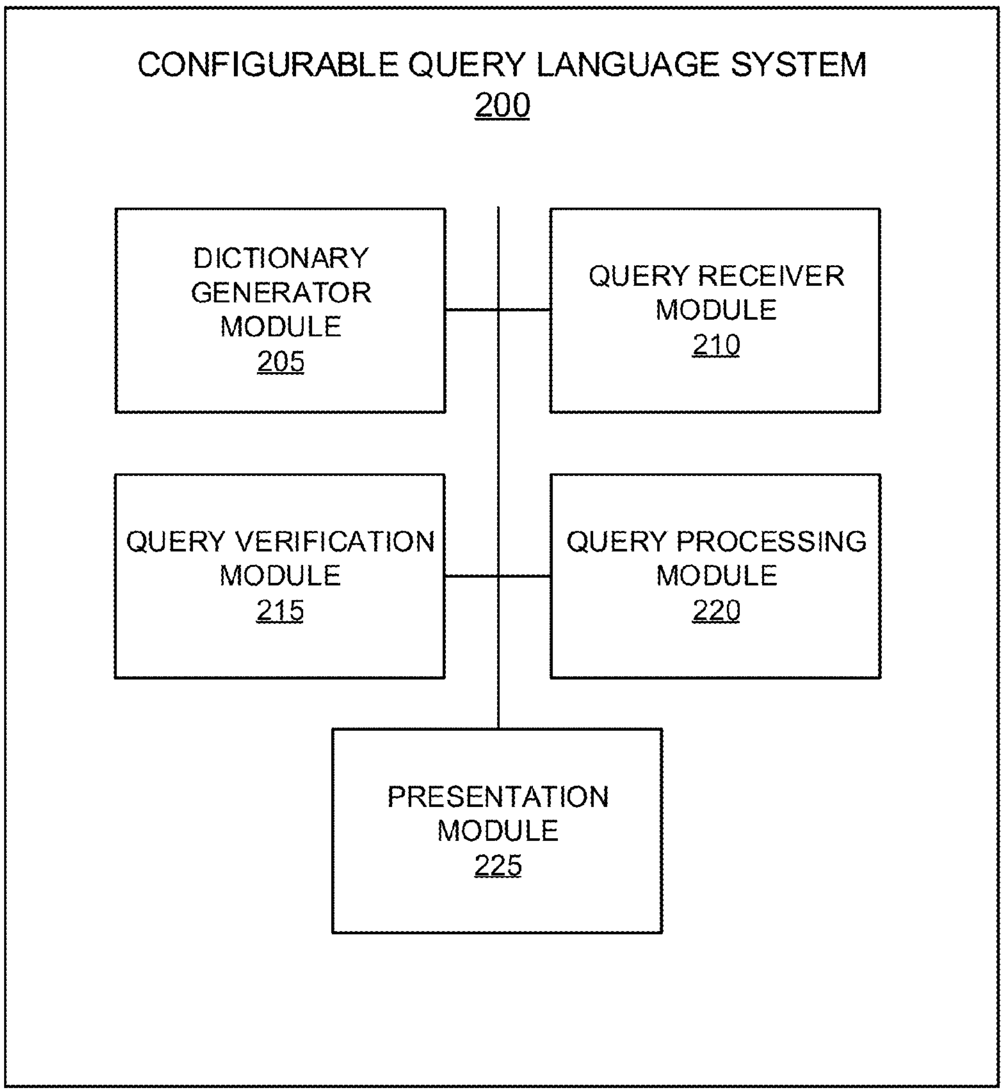
CONFIGURABLE QUERY LANGUAGE SYSTEM
200
DICTIONARY GENERATOR MODULE
205
QUERY RECEIVER MODULE
210
QUERY VERIFICATION MODULE
215
QUERY PROCESSING MODULE
220
PRESENTATION MODULE
225

FIG. 2

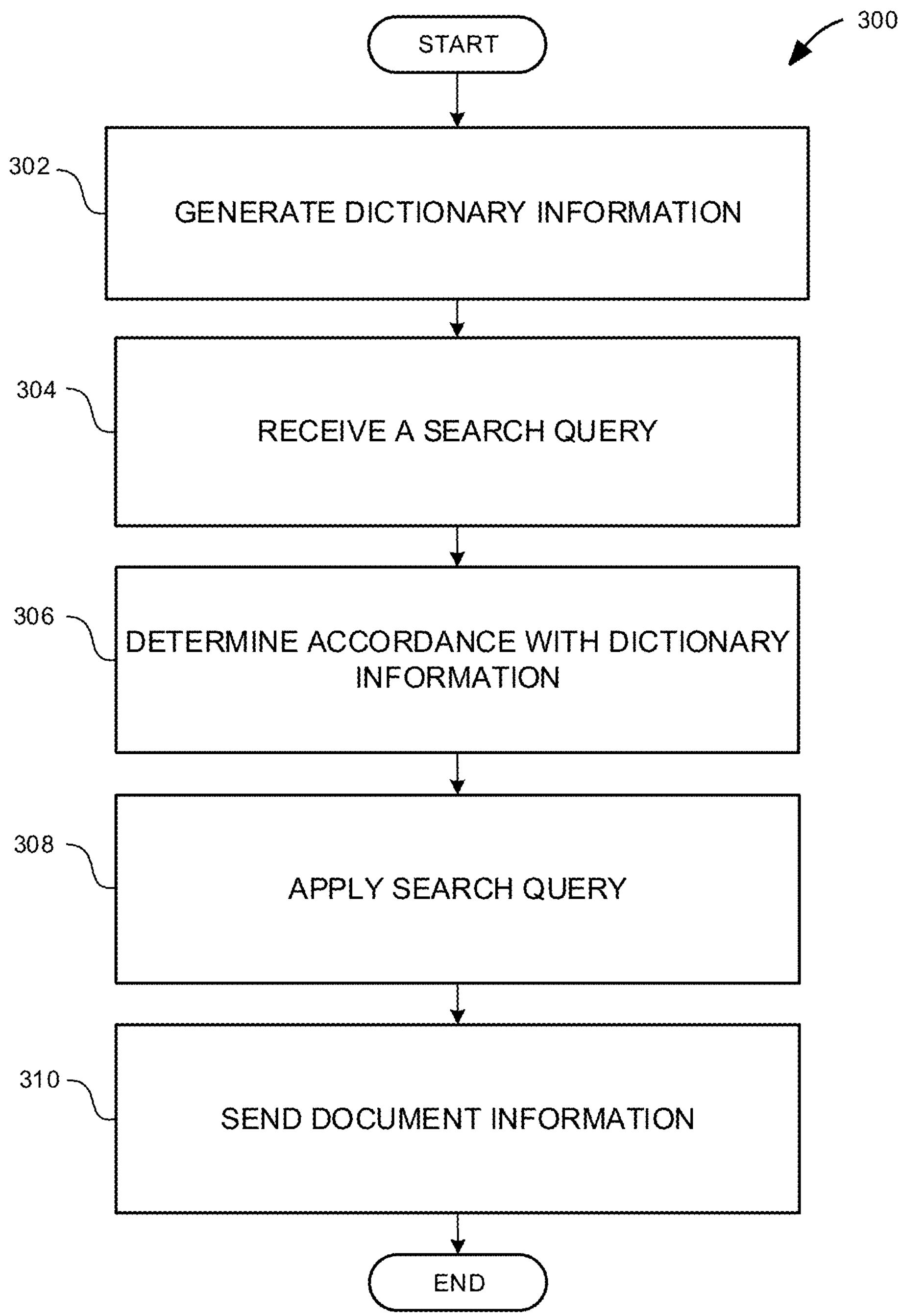
300
START
302
GENERATE DICTIONARY INFORMATION
304
RECEIVE A SEARCH QUERY
306
DETERMINE ACCORDANCE WITH DICTIONARY INFORMATION
308
APPLY SEARCH QUERY
310
SEND DOCUMENT INFORMATION
END

FIG. 3

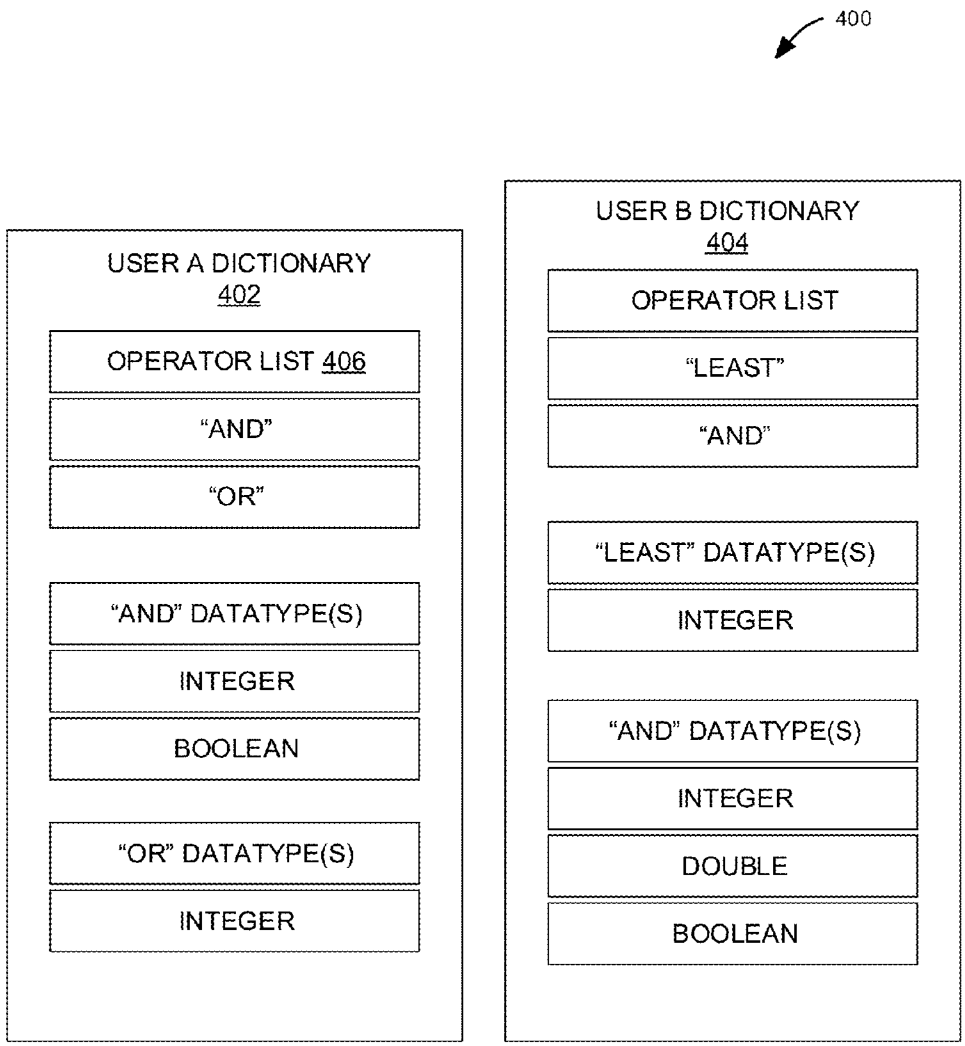
400
USER A DICTIONARY
402
OPERATOR LIST 406
"AND"
"OR"
"AND" DATATYPE(S)
INTEGER
BOOLEAN
"OR" DATATYPE(S)
INTEGER
USER B DICTIONARY
404
OPERATOR LIST
"LEAST"
"AND"
"LEAST" DATATYPE(S)
INTEGER
"AND" DATATYPE(S)
INTEGER
DOUBLE
BOOLEAN

FIG. 4

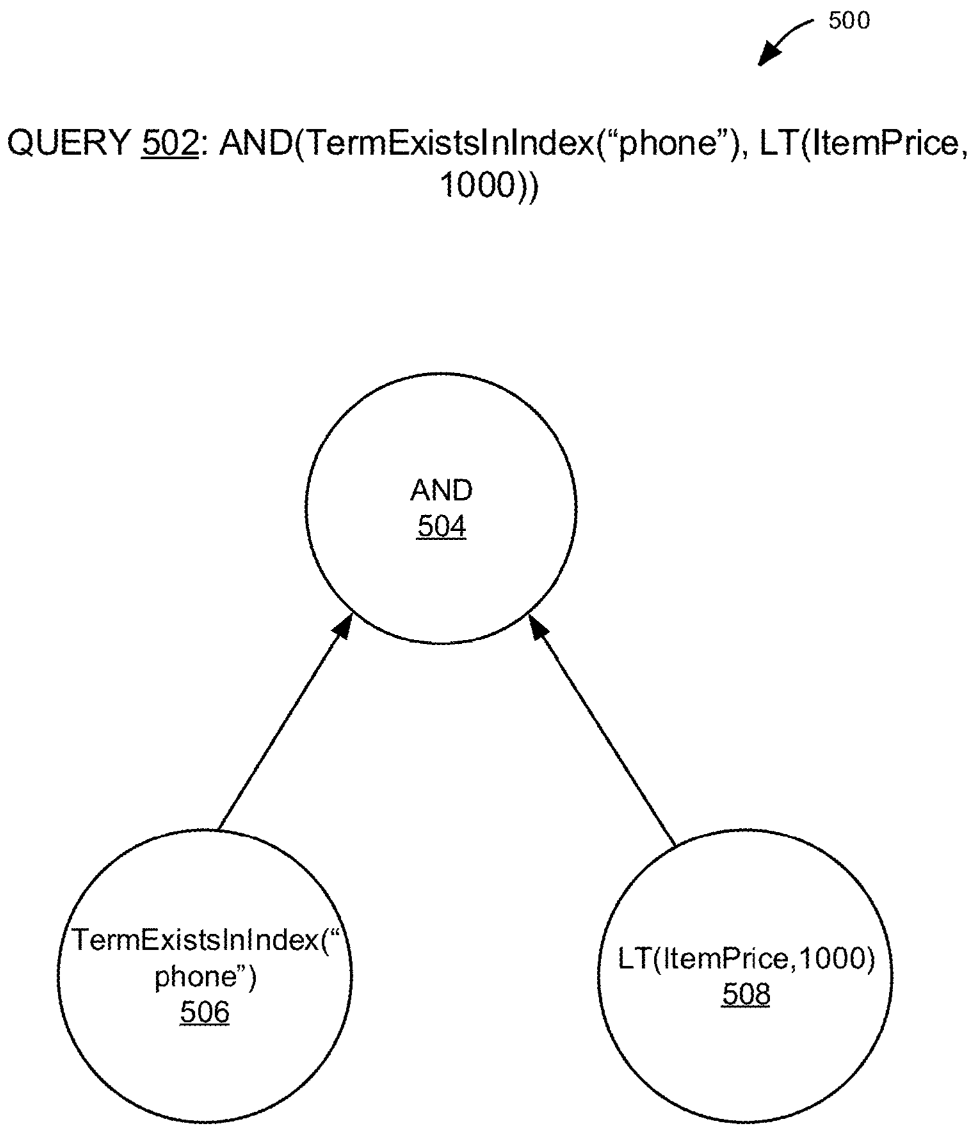
500
QUERY 502: AND(TermExistsInIndex("phone"), LT(ItemPrice, 1000))
AND
504
TermExistsInIndex("phone")
506
LT(ItemPrice,1000)
508

FIG. 5

```
Query Operator Dictionary
Abstract
This document is intend to define a metal format to define Cassini query operators  By
using this format, we can create an operator dictionary which can be recognized and agreed
across different functional components in Cassini architecture.  By specifying the detailed
signature and attribute of each operator, we can easily create the run time checking of the
legitimate usage of the operators in the query expression.

Meta Format
We will try to use JSON to represent the operator syntax.  And the following is the BNF
definition of how we can write the operators.

operator-dictionary = '{'operator-list'}'
operator-list = operator ',' operator-list
              | operator
operator = name':''{'attributes','return','operands',[named-operands'] ['variable-operands-flag']}'
name = string
attributes = 'attributes' ':' attribute-list
attribute-list = '[' attribute-name ',' attribute-list ']'
               | '[' attribute-name ']'
attribute-name = 'return-position' | 'aggregate-function' | 'is-nullable'|'is-required'
value-type = 'bool' | 'int32' | 'uint32' | 'int64' | 'string' | 'float' | 'any'
return = 'return-type' ':' value_type
operands = 'operands' ':' operand-list
named-operands = 'named-operands' ':' named-operand-list
operand-list = '[' operand ',' operand-list ']'
             | '[' operand ']'
named-operand-list = '[' named-operand ',' named-operand-list ']'
             | '[' named-operand ']'
operand = '{' data-type ',' required-attributes '}'
named-operand = '{'operand-name',' data-type ',' required-attributes ', ['default-value']}'
operan-name='name' ':'name
data-type = 'data-type' ':' value_type
required-attributes = attributes
variable-operands-flag = 'variable-repeat-last-operand' ':' ['true' | 'false']
default-value = 'default-value' ':' default-str
default-str = string
```

FIG.6

```
{
  "version":
  {
   "major-version": 1,
   "minor-version": 1
   },
   "operators" :
   {
    "dummy_with_pos":
   {
     "attributes" : [],
     "return-type" : "int64",
     "operands" :
     [
      {
       "attributes" : [],
       "data-type" : "int64"
      }
     ],
     "named-operands" :
     [
      {
       "name" : "name1_required",
       "data-type" : "int64",
       "attributes": ["is-nullable", "is-required"]
       },
       {
        "name" : "name2",
        "data-type" : "float",
        "attributes": ["is-nullable"]
       },
       {
        "name" : "name_has_default",
         "data-type" : "float",
         "attributes": ["is-nullable"],
         "default-value" : "3.3"
         }
       ]
     }
   }
}
```


FIG. 7

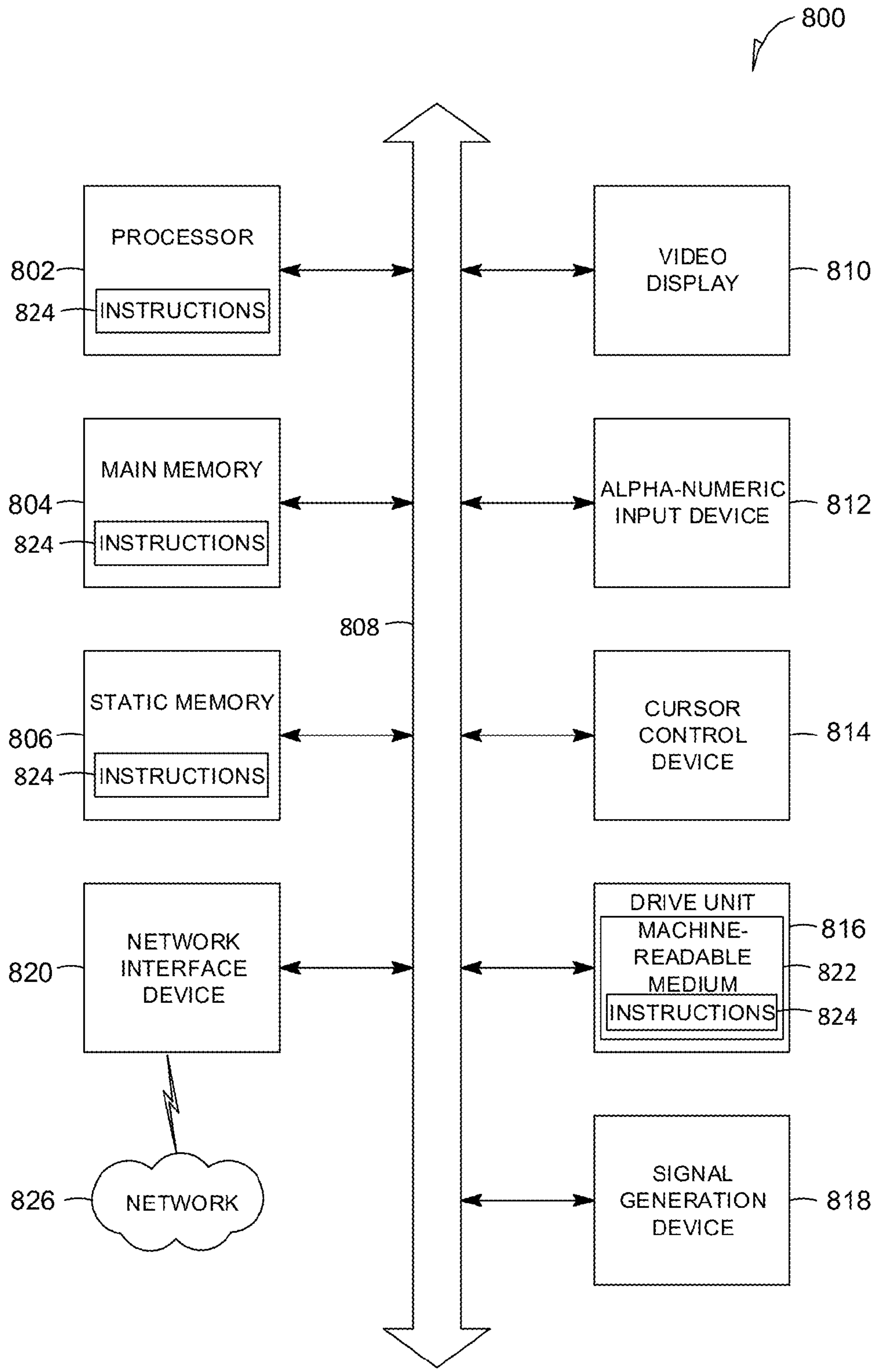
800
PROCESSOR
802
INSTRUCTIONS
824
MAIN MEMORY
804
INSTRUCTIONS
824
808
STATIC MEMORY
806
INSTRUCTIONS
824
NETWORK INTERFACE DEVICE
820
NETWORK
826
VIDEO DISPLAY
810
ALPHA-NUMERIC INPUT DEVICE
812
CURSOR CONTROL DEVICE
814
DRIVE UNIT
816
MACHINE-READABLE MEDIUM
822
INSTRUCTIONS
824
SIGNAL GENERATION DEVICE
818

FIG. 8

SYSTEM AND METHODS TO CONFIGURE A QUERY LANGUAGE USING AN OPERATOR DICTIONARY

RELATED APPLICATIONS

This application is a continuation application of U.S. application Ser. No. 13/759,786, filed Feb. 5, 2013, which claims the priority benefit of U.S. Provisional Application Ser. No. 61/675,793, filed Jul. 25, 2012, all of which are incorporated herein by reference in their entirety.

TECHNICAL FIELD

The present application relates generally to the technical field of data processing and, in one specific example, to configure a query language based on a set of rules for a user.

BACKGROUND

A user may form a search query using a query language to search for information stored within a database. The query may comprise of operators and operands and a server may process the query and retrieve information based on the operators and operands. Once information is retrieved, it may be presented to the user.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments are illustrated by way of example and not limitation in the figures of the accompanying drawings in which:

FIG. **1** is a network diagram depicting a client-server system, where various embodiments may be implemented;

FIG. **2** is a block diagram of a configurable query language system, according to various embodiments;

FIG. **3** is a flowchart of a method to generate an operator dictionary and then verify a query using the operator dictionary, according to various embodiments;

FIG. **4** is a block diagram depicting two operator dictionaries, according to various embodiments;

FIG. **5** is a diagram depicting a query represented as an expression tree, according to various embodiments;

FIG. **6** is a diagram depicting a definition used to define an operator dictionary, according to various embodiments;

FIG. **7** is a diagram depicting an example operator dictionary using the definition depicted in FIG. **6**, according to various embodiments; and

FIG. **8** is a diagram depicting a representation of a machine in the example form of a computer system, according to various embodiments.

DETAILED DESCRIPTION

Example methods and systems to configure a query language using an operator dictionary are described. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of example embodiments. It will be evident, however, to one skilled in the art that the present invention may be practiced without these specific details.

A search query and other forms of input (e.g., sets of text strings, sequences of expressions, collections of verbal and numeric expressions, etc.) may be received as input. For example a search query may be used to query a database using a query language. In various embodiments, terms of the query language comprise of operators and operands. The operands may serve as inputs for the operators. In various embodiments, terms of the query language may be defined by information described in an operator dictionary. The operator dictionary may include a list of compatible operators that may be used in a search query. In various embodiments, operators not listed in the operator dictionary are incompatible and are not processed by a query processer. The operator dictionary may also describe a list of compatible data types for each operator in the list of compatible operators.

In various embodiments, the operator dictionary may correspond to a first user or first group of users. Different customers (e.g., users) may independently provide rules using their own operator dictionary file. As such, rules regarding compatible operators and compatible data types described in the operator dictionary may apply to the first user or first group of users. In various embodiments, there may be other users or group of users forming search queries to query the database. To accommodate the other users, the configure query language system may have more than one operator dictionary for the other user or groups of users forming search queries. All operator dictionary files are, nevertheless, processed by a single query engine that enforces the rules defined in the respective operator dictionaries.

FIG. **1** illustrates a system **10** to build and utilize a search infrastructure, according to an embodiment. The system **10** may include an information storage and retrieval platform **11** that is communicatively coupled over a network (e.g., Internet) (not shown) to a client machine **12** and a client machine **33**.

Illustrated on the top left is an operation A that describes a first user operating the client machine **12** to interact with an application server **14** to store or update a document **16** in a database **18**; illustrated in the middle are operations B, C, D, E that describe retrieving and transforming the contents of the database **18**, storing the transformed contents in a database **20** that is time-stamped, retrieving the contents from the database **20** to generate a full-index **22** and a set of mini-indexes **24** which are utilized to generate and continually update the index information **26** in the database **28** to be consumed and served by the query node servers **30**; and illustrated on the top right is an operation F that describes a second user who operates a client machine **33** to enter a query that is received by one or more query node servers **30** that, in turn, apply the query to the index information **26** to identify and return search results that reference the document **16**. The above operations to continually rebuild the index information **26** are performed in real-time and without interruption to service that is provided to the first and second users who continue to interact with the system **10**.

The index information **26** may include an inverted index **32** and document information **34**. An inverted index (e.g., inverted index **32**), as is well known in the art, is an index data structure storing a mapping from content (e.g., content contained by the document **16**), such as words or numbers, to its locations in a database file, or in a document (e.g., document **16**) or a set of documents. The documents **16** (e.g., document data, column group data) and/or information contained by the documents **16** may be stored in the document information **34**.

Merely for example a "document X" may include the words "apple," "orange," and "banana;" a "document Y" may include the words "apple" and "orange; and, a "document Z" may include the word "apple." An inverted index for the words in documents X, Y, and Z may be generated as follows:

Word	Document
apple	X(1), Y(1), Z(1)
orange	X(2), Y(2)
banana	X(3)

The above inverted index may be utilized to identify the word "apple" as being positioned in the first word of documents X, Y, and Z; the word "orange" as being positioned in the second word of the documents X and Y; and the word "banana" as being positioned as the third word of the document X. Accordingly, the above inverted index may be utilized to map a keyword "apple" contained in a query that is received from a client computer to the documents X, Y, and Z that are further referenced in search results that are returned to the client computer. It is appreciated by one skilled in the art that the inverted index **32** corresponds to the underlying database that it describes. Accordingly, any update to the underlying database is reflected in a corresponding update to the inverted index **32**. Updates to the database **28** may include the addition and deletion of documents **16** in the document information **34** as well as the update of any of the contents contained by the documents **16** in the document information **34**. In the present embodiment, the index information **26** may be updated in real time to respond to a query in real time with accurate search results that include the most recent document information **34**. To this end, the operations A-F are now further described.

The information storage and retrieval platform **11** includes multiple components including the application servers **14** that may execute on one or more application server machines (not shown), the database **18**, a database **20**, an Hadoop distributed file system **23**, the database **28**, the query node servers **30** that operate on query node server machines (not shown), an Hbase/Hadoop Cluster **44** comprised of one or more Hbase/Hadoop machines (not shown) including an Hbase Hadoop Node **49** (e.g, Hbase/Hadoop machine), an index distribution module **52** executing on Hbase/Hadoop machine, search front end servers **58** that executes on search machines (not shown), and search back end servers **60** that execute on search machines (not shown) as being communicatively coupled together. For example, the multiple components may be communicatively coupled with any combination of a wide area network, local area network, wireless network, or any other type of network utilizing various networking technologies.

At operation A, the document **16**, or one or more elements of the document **16**, may be communicated from the client machine **12** to the application servers **14** and stored in the database **18** (e.g., Oracle database). The document **16** may include multiple elements including elements a, b, c, d, e, and f that may include strings of text, numeric information, scores, or other discrete quantum of information that are positioned in different sections or fields of the document (e.g., item information).

At operation B, at the application servers **14**, event manager modules **36** may identify updates to the database **18**, generate events that correspond to the respective updates, prioritize the events according to the quality of the data in the event and communicate the prioritized events into event queues **38** that are consumed by consumer modules **40** that service the respective event queues **38**. According to an embodiment, the event manager modules **36** and the consumer modules **40** may utilize three event queues **38** to process and prioritize event types. For example, the update of the "element a" in the document **16** in the database **18** may be a price change to item information describing an item for sale that causes the generation of a corresponding event that is associated with a high priority that, in turn, is communicated into in a first event queue associated with high priority that, in turn, is received by a consumer module **40**. Similarly, the update of the "element b" in document **16** in the database **18** may be a change to a title of the item that causes the generation of an event that is associated with a medium priority that, in turn, is communicated into a second event queue associated with the medium priority that, in turn, is received by a consumer module **40**. Finally, the update of the "element c" in document **16** in the database **18** may be a change to a description of the item that causes the generation of an event that is communicated into a third event queue associated with a low priority that, in turn, is received by a consumer module **40**. Accordingly, the three event queues **38** may be utilized to communicate events in high, medium, and low priorities to facilitate a preference for the update of high priority events (e.g., price) over medium priority events (e.g., title) over low priority events (e.g., description). In some embodiments the priority for the respective event types may be configured. Other embodiments may include fewer or more event queues **38**.

At operation C, the consumer modules **40** may transform the data in the events and communicate the transformed data via an HBase application programming interface to an HBase master server **42** in an HBase/Hadoop cluster **44** that, in turn, stores the transformed data in one or more tables including an items table **21** in the database **20** (e.g., HBase). The transformed data may be stored according to regions that are managed by region server processes **46**. According to an embodiment, the database **20** may be embodied as an open source non-relational, distributed database (e.g., HBase) that runs on a Hadoop Distributed Filesystem (HDFS) **23**. HDFS **23** is an open source software framework that supports data-intensive distributed applications, known by those skilled in the art. The Hbase/Hadoop cluster **44** may further includes the HBase master server **42** that is utilized to manage the HBase/HDFS environment, a scheduler module **48**, and an HBase/Hadoop node **49** that includes multiple region server processes **46** and a map-reduce job module **50**. Each region server process **46** may further be associated with a column (not shown) that corresponds to a range of documents (e.g., or items corresponding to item information in the items table **21**) and may be utilized to manage one or more regions (not shown) that respectively correspond to a range of the documents **16**. For example, the documents **16** may be uniquely identified with document identifiers (e.g., item identifiers) that are numbered from 0 to X where each column and region are dedicated to respective overlapping predetermined ranges of documents (e.g., documents (0-100 and documents (0-50), as described further in this document. According to one embodiment, the number of region server processes **46** may be in the hundreds but scaling is not limited to any fixed number. HBase is a technology that provides a fault-tolerant way of storing large quantities of sparse data featuring compression, in-memory operation, and a space-efficient probabilistic data structure (e.g., Bloom filters) on a per-column basis as outlined in the original BigTable paper, as is known by those skilled in the art. A table in the database **20** (e.g., HBase) may serve as the input and output for one or more map-reduce jobs that are scheduled by the map-reduce job module **50**. The map-reduce jobs may be embodied as a map jobs and reduce jobs that runs in HDFS. The tables in the database **20** may further be accessed through the Java Application Programming Interface (API) but also through representational state transfer (REST) architecture and other APIs.

At operation D, the scheduler module **48**, executing in the HBase/Hadoop cluster **44**, may schedule two index generating sub-operations that process in parallel to generate indexes that are subsequently distributed to the query node servers **30**. The sub-operations may execute for the generating of a full-index **22** and the generating of the mini-indexes **24**. The sub-operations may further execute for the distribution of the indexes to the query node servers **30**. The full-index **22** may be a snapshot of the contents of items table **21** in the database **20** and the mini-indexes **24** may respectively correspond to a series of consecutive snapshots where each snapshot captures one or more updates to the items table **21** in the database **20** that occurred within an associated time period of time. The distribution of the full-indexes **22** and the mini-indexes **24** to the query node servers **30** may be over a network utilizing an index distribution module **52** which is based on Bit Torrent, a peer to peer file sharing protocol. In one embodiment, the scheduler module **48** may schedule the generation of the full-index **22** twice in a twenty-four hour period and the generation of mini-indexes **24** every five minutes. The scheduler module **48** may generate a full-index **22** that is associated with a start-time by scheduling a map-reduce job module **50**. The map-reduce job module **50** may initiate a map step that divides the job into smaller sub-jobs (e.g., map tasks) and multiple reduce steps that consume the output from the sub jobs and aggregates results to generate the index information **26**. Similarly, the scheduler module **48** may generate a mini-index **24** by scheduling a map-reduce job module **50** for execution on the Hbase/Hadoop Node **49** may include a map step but not, according to one embodiment, a reduce step. Accordingly, each mini-index **24** may be associated with events that arrive from the event queues **38** during a particular period of time and is associated with one or more full-indexes **22**. Each index **22**, **24** (e.g., full and mini) may include a bill of material (BOM) information which describes the content of the index **22**, **24** including the index information **26**. The full-index **22** may include full-index BOM information **54** and the mini-index **24** may include mini-index BOM information **56**. The index information **26** may include the inverted index **32** and document information **34**, as previously described.

At operation E, each of the query node servers **30** may receive the full-index **22** and the associated mini-indexes **24**. The query node servers **30** may be comprised of a search grid that is arranged in columns of query node servers **30**, as described later in this document. Each column of query node serves **30** and may be utilized to manage a range of the documents **16** (e.g., column), as previously mentioned. The index information **26** may be stored in memory of the query node servers **30** and in the database **28** connected to the query node servers **30**. The index information **26** may be updated with the full-index **22** responsive to its arrival at the query node servers **30**. Further, the index information **26** may be updated with the mini-index **24** responsive to its arrival at the query node servers **30**. The index information **26** is generally updated in sequential order. For example, the index information **26** are generally updated at the query node server **30** in the order in which the full-index **22** and the mini-indexes **24** are generated. To this end, the full-index **22** may be associated with full-index BOM information **54** the mini-index **24** may be associated with mini-index BOM information **56** that are utilized by the query node server **30** to manage the update of the index information **26**. In one embodiment a map-reduce job module **50** may include sub jobs that execute on the Hbase/Hadoop node **49** to generate inverted indices in the form of region sub-indices (not shown) for part of the region associated with the region server (HBase). The sub jobs may further merge or stitch the multiple region sub-indices together for the region.

At operation F, a second user who operates the client machine **33** may enter a query that may be communicated over a network (e.g., Internet) via front-end servers **58** and back-end servers **60** to be received by the query node servers **30** which may be divided into two layers. The two layers may include an aggregation layer and a query execution layer. The aggregation layer may include a query node server **30** that includes a query engine **62** (e.g., query module) that receives the query that, in turn, communicates the query to multiple query engines **62** that respectively execute in the execution layer in multiple query node servers **30** that correspond to the columns. The query engines **62** in the query execution layer may, in turn, respectively apply the same query, in parallel, against respective the index information **26** that were generated for a range of document identifiers (e.g., column) to identify search results (e.g., document **16**) in parallel. Finally, the query engines **62**, at each query node servers **30** in the query execution layer, may communicate their respective partial search results to the query engine **62** in the aggregation layer which aggregates the multiple sets of partial search results to form a search result for the entire index information **26** and to communicate the search result over the network to the second user.

FIG. **2** is a block diagram of a configurable query language system **200**, according to various embodiments. The system **200** may be implemented as hardware or as software executed by hardware (e.g., by one or more processors) comprises a dictionary generator module **205**, a query receiver module **210**, a query verification module **215**, a query processing module **220**, and a presentation module **225**.

In various embodiments, the dictionary generator module **205** may be configured to generate an operator dictionary corresponding to a user or group of users. The information described in the operator dictionary may describe the terms of a query language that may be used in a search query. For instance, the operator dictionary may describe a list of compatible operators. An operator that is listed as a compatible operator may be processed by the query processing module **220** for the user of group of users. In various embodiments, if the corresponding user or group of users forms a query using an operator not listed in the operator dictionary, then the system **200** may not process the query. Each operator described in the operator dictionary may perform an operation on input data, also known as an operand. In various embodiments, an operator may operate on at least one operand. Operands may also be of various data types. In some instances, an operand may be an integer, a string, a double, and the like. An operator may perform an operation using operands of various data types. For example, the operator "AND" may perform an operation using an operand of the string data type and an operand of the integer data type. Moreover, the result of an operation performed by an operator may also be of various data types. The operator dictionary may describe a list of compatible data types to be used in connection with each operator in the operator dictionary. The list of compatible data types may describe compatible input data types for an operator. The list of compatible data types may also describe output data types for an operator.

In various embodiments, the query verification module **215** may be configured to determine that the terms of the search query are in accordance with the operator dictionary. The query verification module **215** may determine that an operator in the search query is listed as a compatible operator in the operator dictionary. A compatible operator may be processed by the query processing module **220**. Alternatively, the query verification module **215** may determine that an operator in the search query is not listed as a compatible operator in the operator dictionary and not processed by the query processing module **220**. The query verification module **215** may also determine that an input to an operator in the search query is of a compatible data type for the operator, as described in the list of compatible data types. The query verification module **215** may also determine that an output from an operator is of a compatible data type for the operator, as described in the list of compatible data types. In various embodiments, a search query is determined to be in accordance with the operator dictionary if all of its operators are listed as a compatible operator in the operator dictionary and if all of the input data types and output data types for each operator are described as a compatible data type.

In various embodiments, the query may be represented as an expression tree of nodes that are connected to one another. Each node in the expression tree may include an operator or an operand. The nodes may also be arranged according to a parent-child hierarchy, in which parent nodes are represented at a level higher than child nodes. A parent node may be connected with at least one child node. In various embodiments, data included in the at least one child node may be an input to the operator included in the parent node. The query verification module **215** may verify a search query represented as an expression tree determining that data included in a child node is listed as a compatible data type for an operator included in the parent of the child. Moreover, the query verification module **215** may determine that the operator included in a parent node is listed as a compatible operator the in the operator dictionary. The query verification module **215** may traverse the expression tree until all of the nodes in the expression tree are evaluated. In various embodiments, a search query is determined to be in accordance with the operator dictionary if all of its operators are listed as a compatible operator in the operator dictionary and if all of the input data types and output data types for each operator are described as a compatible data type.

In various embodiments, more than one user or group of users may submit a query to the system **200**. As such, the dictionary generator module **205** may generate an additional operator dictionary. The additional operator dictionary may correspond to the other user or group of users. In some instances, the additional operator dictionary may be identical to the first operator dictionary. Alternatively, the additional operator dictionary may be different from the first operator dictionary. In various embodiments, the list of compatible operators from the first operator dictionary may be different from the list of compatible operators from the additional operator dictionary. In various embodiments, the list of compatible data types from the first operator dictionary may be different from the list of compatible data types from the additional operator dictionary. In various embodiments, because the operator dictionaries are different, terms of a search query that conforms to rules listed in the first operator dictionary may be in violation of rules listed in the additional operator dictionary. Moreover, terms of a search query that conforms to the rules listed in the additional operator dictionary may be in violation of the rules listed in the first operator dictionary.

In various embodiments, the query verification module **215** may be configured to determine that the terms of the query from a user or group of users are in accordance with the operator dictionary corresponding to the user or group of users. For instance, a first user may submit a first query with terms that are in accordance with a first operator dictionary. Additionally, a second user may submit a second query with terms that are identical to the first query but the second query may not be in accordance with the second operator dictionary corresponding to the second user, even though the first and second queries are identical. In this way, the system **200** may define the query language used by the first user to be different from the query language used by the second user based on the operator dictionary generated by the dictionary generator module **205**. Alternatively, the system **200** may define the query language used by the first user to be the same as the query language used by the second user based on the operator dictionary generated by the dictionary generator module **205**.

In various embodiments, the query receiver module **210** may be configured to receive a query from a user to search for document information in the database(s) **26** of FIG. **1**. The query receiver module **210** may receive queries from a plurality of users and the queries from each user may be different.

In various embodiments, as soon as the query is verified by the query verification module **215**, the query processing module **220** may send the query to the query node servers **24** of FIG. **1** in order to be processed.

In various embodiments, the presentation module **225** may be configured to send the retrieved document information **21** of FIG. **1** back to the user that submitted the search query.

FIG. **3** is a flowchart of a method **300** to generate an operator dictionary and then verify a query using the operator dictionary, according to various embodiments. The method begins at step **302** when the dictionary generator module **205** generates dictionary information that corresponds to a first user. In various embodiments, the dictionary information may include a first list of compatible query operators and a description of compatible data types that correspond to each operator in the first list of compatible query operators. At step **304**, the query receiver module **210** may receive, from the first user, a search query to search for document information in a database. In various embodiments, the database may include an inverted index. At step **306**, the query verification module **215** may determine that terms of the search query from the first user are in accordance with the dictionary information that corresponds to the first user. In various embodiments, the query verification module **215** may determine that an operator in the search query is included in the first list of compatible query operators. In various embodiments, the query verification module **215** may determine that an input to an operator in the search query is described as a compatible data type that is included in the description of compatible data types. In various embodiments, the query verification module **215** may determine that an output of an operation corresponding to an operator in the search query is described as a compatible data type. At step **308**, the query processing module **220** may apply the search query to the inverted index in the database to identify the document information. And at step **310**, the presentation module **225** may send the document information to the first user.

FIG. **4** is a block diagram **400** depicting two operator dictionaries, according to various embodiments. As mentioned previously, an operator dictionary may correspond to a user or a group of users. In this diagram **400**, operator dictionary **402** corresponds to user A and operator dictionary **404** corresponds to user B. In various embodiments, queries formed by user A may be verified using dictionary **402** and queries formed by user B may be verified using dictionary B. In various embodiments, an operator dictionary **402** may include a list of compatible operators **406**. In this particular embodiments, the list of compatible operators **406** includes the operators "AND" and "OR." There may also be a list of compatible data types for each operator from the list of compatible operators. FIG. **4** depicts a list of compatible data types **408** for the "AND" operator and a list of compatible data types **410** for the "OR" operator. As depicted in FIG. **4**, operator dictionaries may be different from one another. The list of operators from operator dictionary **402** is different from the list operators from operator dictionary **404**. In various embodiments, FIG. **4** depicts a visual representation of an operator dictionary. However, this depiction is only one particular embodiment. In various embodiments, the operator dictionary may not be represented in the same manner.

FIG. **5** is a diagram **500** depicting a query represented as an expression tree, according to various embodiments. In various embodiments, a query **502** may be represented in the form of a tree **504** where each term of the query **502** is represented as a node of the expression tree **504**. As depicted in FIG. **5**, the "AND" operator from the query **502** is represented at node **504**. The "AND" operator may also operate on two inputs. In FIG. **5**, the inputs to the "AND" operator are represented by node **506** and node **508**. As mentioned previously, the expression tree **504** may be arranged according to the parent-child hierarchy. In various embodiments, node **506** and node **508** are child nodes of parent node **504**.

FIG. **6** is a diagram depicting a definition **600** used to define an operator dictionary, according to various embodiments.

FIG. **7** is a diagram depicting an example operator dictionary **700** using the definition depicted in FIG. **6**, according to various embodiments.

Modules, Components and Logic

Certain embodiments are described herein as including logic or a number of components, modules, or mechanisms. Modules may constitute either software modules (e.g., code embodied (1) on a non-transitory machine-readable medium or (2) in a transmission signal) or hardware-implemented modules. A hardware-implemented module is tangible unit capable of performing certain operations and may be configured or arranged in a certain manner. In example embodiments, one or more computer systems (e.g., a standalone, client or server computer system) or one or more processors may be configured by software (e.g., an application or application portion) as a hardware-implemented module that operates to perform certain operations as described herein.

In various embodiments, a hardware-implemented module may be implemented mechanically or electronically. For example, a hardware-implemented module may comprise dedicated circuitry or logic that is permanently configured (e.g., as a special-purpose processor, such as a field programmable gate array (FPGA) or an application-specific integrated circuit (ASIC)) to perform certain operations. A hardware-implemented module may also comprise programmable logic or circuitry (e.g., as encompassed within a general-purpose processor or other programmable processor) that is temporarily configured by software to perform certain operations. It will be appreciated that the decision to implement a hardware-implemented module mechanically, in dedicated and permanently configured circuitry, or in temporarily configured circuitry (e.g., configured by software) may be driven by cost and time considerations.

Accordingly, the term "hardware-implemented module" should be understood to encompass a tangible entity, be that an entity that is physically constructed, permanently configured (e.g., hardwired) or temporarily or transitorily configured (e.g., programmed) to operate in a certain manner and/or to perform certain operations described herein. Considering embodiments in which hardware-implemented modules are temporarily configured (e.g., programmed), each of the hardware-implemented modules need not be configured or instantiated at any one instance in time. For example, where the hardware-implemented modules comprise a general-purpose processor configured using software, the general-purpose processor may be configured as respective different hardware-implemented modules at different times. Software may accordingly configure a processor, for example, to constitute a particular hardware-implemented module at one instance of time and to constitute a different hardware-implemented module at a different instance of time.

Hardware-implemented modules can provide information to, and receive information from, other hardware-implemented modules. Accordingly, the described hardware-implemented modules may be regarded as being communicatively coupled. Where multiple of such hardware-implemented modules exist contemporaneously, communications may be achieved through signal transmission (e.g., over appropriate circuits and buses) that connect the hardware-implemented modules. In embodiments in which multiple hardware-implemented modules are configured or instantiated at different times, communications between such hardware-implemented modules may be achieved, for example, through the storage and retrieval of information in memory structures to which the multiple hardware-implemented modules have access. For example, one hardware-implemented module may perform an operation, and store the output of that operation in a memory device to which it is communicatively coupled. A further hardware-implemented module may then, at a later time, access the memory device to retrieve and process the stored output. Hardware-implemented modules may also initiate communications with input or output devices, and can operate on a resource (e.g., a collection of information).

The various operations of example methods described herein may be performed, at least partially, by one or more processors that are temporarily configured (e.g., by software) or permanently configured to perform the relevant operations. Whether temporarily or permanently configured, such processors may constitute processor-implemented modules that operate to perform one or more operations or functions. The modules referred to herein may, in some example embodiments, comprise processor-implemented modules.

Similarly, the methods described herein may be at least partially processor-implemented. For example, at least some of the operations of a method may be performed by one or processors or processor-implemented modules. The performance of certain of the operations may be distributed among the one or more processors, not only residing within a single machine, but deployed across a number of machines. In some example embodiments, the processor or processors may be located in a single location (e.g., within a home environment, an office environment or as a server farm), while in other embodiments the processors may be distributed across a number of locations.

The one or more processors may also operate to support performance of the relevant operations in a "cloud computing" environment or as a "software as a service" (SaaS). For example, at least some of the operations may be performed by a group of computers (as examples of machines including processors), these operations being accessible via a network (e.g., the Internet) and via one or more appropriate interfaces (e.g., Application Program Interfaces (APIs).)

Electronic Apparatus and System

Example embodiments may be implemented in digital electronic circuitry, or in computer hardware, firmware, software, or in combinations of them. Example embodiments may be implemented using a computer program product, e.g., a computer program tangibly embodied in an information carrier, e.g., in a machine-readable medium for execution by, or to control the operation of, data processing apparatus, e.g., a programmable processor, a computer, or multiple computers.

A computer program can be written in any form of programming language, including compiled or interpreted languages, and it can be deployed in any form, including as a stand-alone program or as a module, subroutine, or other unit suitable for use in a computing environment. A computer program can be deployed to be executed on one computer or on multiple computers at one site or distributed across multiple sites and interconnected by a communication network.

In example embodiments, operations may be performed by one or more programmable processors executing a computer program to perform functions by operating on input data and generating output. Method operations can also be performed by, and apparatus of example embodiments may be implemented as, special purpose logic circuitry, e.g., a field programmable gate array (FPGA) or an application-specific integrated circuit (ASIC).

The computing system can include clients and servers. A client and server are generally remote from each other and typically interact through a communication network. The relationship of client and server arises by virtue of computer programs running on the respective computers and having a client-server relationship to each other. In embodiments deploying a programmable computing system, it will be appreciated that that both hardware and software architectures require consideration. Specifically, it will be appreciated that the choice of whether to implement certain functionality in permanently configured hardware (e.g., an ASIC), in temporarily configured hardware (e.g., a combination of software and a programmable processor), or a combination of permanently and temporarily configured hardware may be a design choice. Below are set out hardware (e.g., machine) and software architectures that may be deployed, in various example embodiments.

Example Machine Architecture and Machine-Readable Medium

FIG. **8** is a diagram depicting a representation of a machine in the example form of a computer system **800**, according to various embodiments. In alternative embodiments, the machine operates as a standalone device or may be connected (e.g., networked) to other machines. In a networked deployment, the machine may operate in the capacity of a server or a client machine in server-client network environment, or as a peer machine in a peer-to-peer (or distributed) network environment. The machine may be a personal computer (PC), a tablet PC, a set-top box (STB), a Personal Digital Assistant (PDA), a cellular telephone, a web appliance, a network router, switch or bridge, or any machine capable of executing instructions (sequential or otherwise) that specify actions to be taken by that machine. Further, while only a single machine is illustrated, the term "machine" shall also be taken to include any collection of machines that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein.

The example computer system **800** includes a processor **802** (e.g., a central processing unit (CPU), a graphics processing unit (GPU) or both), a main memory **804** and a static memory **806**, which communicate with each other via a bus **808**. The computer system **800** may further include a video display unit **810** (e.g., a liquid crystal display (LCD) or a cathode ray tube (CRT)). The computer system **800** also includes an alphanumeric input device **812** (e.g., a keyboard or a touch-sensitive display screen), a user interface (UI) navigation device **814** (e.g., a mouse), a disk drive unit **816**, a signal generation device **818** (e.g., a speaker) and a network interface device **820**.

Machine-Readable Medium

The disk drive unit **816** includes a machine-readable medium **822** on which is stored one or more sets of instructions and data structures (e.g., software) **824** embodying or utilized by any one or more of the methodologies or functions described herein. The instructions **824** may also reside, completely or at least partially, within the main memory **804** and/or within the processor **802** during execution thereof by the computer system **800**, the main memory **804** and the processor **802** also constituting machine-readable media.

While the machine-readable medium **822** is shown in an example embodiment to be a single medium, the term "machine-readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more instructions or data structures. The term "machine-readable medium" shall also be taken to include any tangible medium that is capable of storing, encoding or carrying instructions for execution by the machine and that cause the machine to perform any one or more of the methodologies of the present invention, or that is capable of storing, encoding or carrying data structures utilized by or associated with such instructions. The term "machine-readable medium" shall accordingly be taken to include, but not be limited to, solid-state memories, and optical and magnetic media. Specific examples of machine-readable media include non-volatile memory, including by way of example semiconductor memory devices, e.g., Erasable Programmable Read-Only Memory (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM), and flash memory devices; magnetic disks such as internal hard disks and removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks.

Transmission Medium

The instructions **824** may further be transmitted or received over a communications network **826** using a transmission medium. The instructions **824** may be transmitted using the network interface device **820** and any one of a number of well-known transfer protocols (e.g., HTTP). Examples of communication networks include a local area network ("LAN"), a wide area network ("WAN"), the Internet, mobile telephone networks, Plain Old Telephone (POTS) networks, and wireless data networks (e.g., WiFi and WiMax networks). The term "transmission medium" shall be taken to include any intangible medium that is capable of storing, encoding or carrying instructions for execution by the machine, and includes digital or analog communications signals or other intangible media to facilitate communication of such software.

Although an embodiment has been described with reference to specific example embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the invention. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. The accompanying drawings that form a part hereof, show by way of illustration, and not of limitation, specific embodiments in which the subject matter may be practiced. The embodiments illustrated are described in sufficient detail to enable those skilled in the art to practice the teachings disclosed herein. Other embodiments may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. This Detailed Description, therefore, is not to be taken in a limiting sense, and the scope of various embodiments is defined only by the appended claims, along with the full range of equivalents to which such claims are entitled.

Such embodiments of the inventive subject matter may be referred to herein, individually and/or collectively, by the term "invention" merely for convenience and without intending to voluntarily limit the scope of this application to any single invention or inventive concept if more than one is in fact disclosed. Thus, although specific embodiments have been illustrated and described herein, it should be appreciated that any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the above description.

What is claimed is:

1. A system comprising:
- a processor and executable instructions accessible on a computer-readable medium that, when executed, cause the processor to perform operations comprising:
- receive, from a first user, a search query to search for document information in a database, the database including an index data structure;
- determine that terms of the search query are in accordance with dictionary information that corresponds to the first user, the dictionary information for the first user including a first list of compatible query operators;
- apply the search query to the index data structure in the database to identify the document information; and
- send an electronic interface to the first user, the electronic interface including the document information.

2. The system of claim **1**, wherein the executable instructions cause the processor to further perform the operations comprising:
- generate dictionary information that corresponds to a second user, the dictionary information that corresponds to the second user includes a second list of compatible query operators and a description of compatible data types that correspond to each operator in the second list of compatible query operators, wherein the dictionary information that corresponds to the second user is different from the dictionary information that corresponds to the first user.

3. The system of claim **2**, wherein the executable instructions cause the processor to further perform the operations comprising:
- receive, from the second user, a search query to search for document information in the database, wherein the search query from the second user is different than the search query from the first user.

4. The system of claim **3**, wherein the executable instructions cause the processor to further perform the operations comprising:
- determine, using one or more processors, that the terms of the search query from the second user are in accordance with the dictionary information corresponding to the second user.

5. The system of claim **2**, wherein the executable instructions cause the processor to further perform the operations comprising:
- receive, from the second user, a search query to search for document information in the database, wherein the search query from the second user is identical to the search query from the first user.

6. The system of claim **5**, wherein the executable instructions cause the processor to further perform the operations comprising:
- determine, using one or more processors, that the terms of the search query from the second user are not in accordance with the dictionary information corresponding to the second user.

7. The system of claim **1**, wherein the executable instructions cause the processor to further perform the operations comprising:
- determine that an operator in the search query is included in the first list of compatible query operators.

8. The system of claim **1**, wherein the executable instructions cause the processor to further perform the operations comprising:
- determine that an input to an operator in the search query is described as a compatible data type that is included in the description of compatible data types.

9. The system of claim **1**, wherein the executable instructions cause the processor to further perform the operations comprising:
- determine that an output of an operation corresponds to an operator in the search query is described as a compatible data type.

10. The system of claim **1**, wherein the search query is arranged as an expression tree that includes at least one child node coupled to at least one parent node and wherein data included in the at least one child node is an input to an operator included in the at least one parent node.

11. The system of claim **10**, wherein the executable instructions cause the processor to further perform the operations comprising:
- determine that the data included in the at least one child node is described as a compatible data type to the operator included in the at least one parent node.

12. A method comprising:
- receiving, from a first user, a search query to search for document information in a database, the database including an index data structure;
- determining that terms of the search query are in accordance with dictionary information corresponding to the

first user, the dictionary information including a first list of compatible query operators;

applying the search query to the index data structure in the database to identify the document information; and

sending an electronic interface to the first user, the electronic interface including the document information.

13. The method of claim **12**, further comprising:

generating dictionary information corresponding to a second user, the dictionary information corresponding to the second user including a second list of compatible query operators and a description of compatible data types that correspond to each operator in the second list of compatible query operators, wherein the dictionary information corresponding to the second user is different from the dictionary information corresponding to the first user.

14. The method of claim **13**, further comprising:

receiving, from a second user, a search query to search for document information in the database, wherein the search query from the second user is different than the search query from the first user.

15. The method of claim **14**, further comprising:

determining that the terms of the search query from the second user are in accordance with the dictionary information corresponding to the second user.

16. The method of claim **13**, further comprising:

receiving, from the second user, a search query to search for document information in the database, wherein the search query from the second user is identical to the search query from the first user.

17. The method of claim **16**, further comprising:

determining the terms of the search query from the second user are not in accordance with the dictionary information corresponding to the second user.

18. The method of claim **12**, wherein the search query is arranged as an expression tree including at least one child node coupled to at least one parent node and wherein data included in the at least one child node is an input to an operator included in the at least one parent node.

19. The method of claim **18**, wherein the determining that terms of the search query are in accordance with the dictionary information includes determining that the data included in the at least one child node is described as a compatible data type to the operator included in the at least one parent node.

20. A non-transitory machine-readable medium storing instructions which, when executed by one or more processors, cause the one or more processors to perform operations comprising:

receiving, from a first user, a search query to search for document information in a database, the database including an index data structure;

determining that terms of the search query from the first user are in accordance with dictionary information corresponding to the first user, the dictionary information including a first list of compatible query operators;

applying the search query to the index data structure in the database to identify the document information; and

sending an electronic interface to the first user, the electronic interface including the document information.

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